IMPERIAL BUREAU OF ANIMAL NUTRITION

Technical Communication No. 4

Problems of Animal Nutrition and Animal Husbandry in Northern Nigeria

BY

A. W. ANDERSON, B.Sc.

WITH A FOREWORD BY

O. T. FAULKNER, C.M.G., B.A.

Director of Agriculture, Nigeria

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FOREWORD.

I HAVE been asked to write a foreword to this paper. This I do with much pleasure ; for this work was planned, and Mr. Anderson reviews the results, mainly from the point of view of the possible improvement of the nomadic herds of Nigeria. We—that is the Agricultural Department of Nigeria—are chiefly interested in the data from another point of view.

When the subject of the improvement of cattle was taken up by the Agricultural Department it was clear that there were two distinct problems, the improvement of the nomadic herds and the improvement of the cattle kept by farmers. In each case it was clear that improvement of the cattle must be preceded by an improvement of their diet. This consideration immediately placed the improvement of the cattle of the nomadic herds in the position of a side-line in our programme of cattle breeding. Whether any improvement of their diet was feasible at all was highly problematical. Any improvement that might be feasible was clearly very limited, for the nomadic Fulani herdsman would never use fodders, and could hardly be expected to use concentrates to any considerable extent. Practical, economically feasible improvement of the food of these cattle might be said to be limited to the supply of any mineral that may be deficient in the grazing. This, in turn, clearly limited any feasible improvement in the cattle to a possible increase in rate of growth and ultimate size ; and even in these directions the possible degree of improvement was again obviously but small, since it could not be expected that such a poor diet would be vastly improved merely by making good a possible mineral deficiency, without any addition to its energy value.

Messrs. Anderson and Hartley's experiments indicate that it is not really feasible to improve the diet of the cattle of the nomadic herds at all, and hence that there is no possibility of substantially improving those cattle. This is a very valuable result. For it indicates that not merely should we make the improvement of the

farmers' cattle our main objective, as was our intention, but that we should make it our sole objective.

In Part IV. Mr. Anderson records the results of various enquiries among native herdsmen, and the conclusions to which those enquiries led him. I fear that not every one with knowledge of this subject will agree with every " statement of fact " which Mr. Anderson makes in that part of the paper, still less with every view he expresses therein. This is inevitable in the nature of the case. But I think that the most important of his facts—those relating to economic considerations —and the deduction to which these facts lead him, are all incontrovertible. That deduction is the same as his deduction from the experiments recorded in the first three parts of his paper.

Since most of the cows at present belong to the nomadic herdsmen, it may appear illogical to regard the improvement of the farmers' cattle as meriting a considerable effort by Government. But we are not concerned only with the improvement of the cattle already kept by farmers, although that number is by no means inconsiderable. We have to look to the future. Cattle improvement is slow work and there is no doubt that before we have many superior bulls available, it will come about, as a result of the work of the Agricultural Department in introducing " mixed farming "—ploughing with cattle and manure making—that many more farmers than at present will own cows. Once a farmer has taken to ploughing and making farmyard manure, he very soon wants also to keep cows, in order to utilise profitably his surplus products and spare labour and further to increase his supply of manure. This desire is already evident. It seems that the only thing which hinders the more rapid increase of cow-keeping by farmers is the fact that the Fulani herdsmen will hardly sell even poor cows at even a high price. If we could buy average, reasonably good cows (good by present standards) at anything like a reasonable price, we could immediately sell a considerable number to farmers ; but we cannot buy them. This is the great difficulty and it is a very real one. But when the economic force leading in any direction is so strong as is that which leads in this direction, such an obstacle must surely be overcome in time. The work of the Veterinary Department in lessening the annual losses of cattle should in time help to render more cows available for farmers. Once the cows are in the farmers' hands, then the obstacles to improving their milking capacity vanish ; and the improvement of the cows will in turn greatly increase the economic force which tends towards cow-keeping by farmers. For if

it is profitable to farmers, as they obviously find it, to keep cows that give 100 gallons of milk a year (or less), how much more profitable would it be if they could obtain 300 gallon cows ?

Once a man has taken up ploughing, then no longer are all his energies and all the energies of all his family absorbed throughout the rainy season in a desperate race against time. He now has fields and labour to spare except during one quite short period, and on that land and with that labour he can grow fodder crops, once the right fodder crops have been found for him. Even at the busiest time of the year he only ploughs in the morning and evening, and he could make hay at that time. Again, by increasing the area of his farm he has trebled his supply of the by-products of the farm, the haulms of groundnuts and beans, the leaves and bran of guinea corn. There are nutritional problems to be solved even for the farmer ; but they are problems that are certainly soluble ; and Messrs. Anderson and Hartley's work, although they planned it with their eyes upon the nomadic herds, has a bearing also upon the farmer's nutritional problems.

Viewing their work from this point of view, two important facts stand out. One of these facts is that growing cattle, even in Zaria province, when living by grazing alone, lose 48 lbs., on the average, during the dry season. Parenthetically it may be mentioned that a repetition of Mr. Anderson's experiment this year has again given, by what must be to some extent a coincidence, almost exactly the same figure. Such a loss of weight among growing cattle is clearly a matter of the greatest importance. It has always been realised that grazing cattle in the northern provinces are regularly partially starved in the dry weather ; but an actual quantitative proof of this fact is most valuable. It is obvious that if cattle are going to be kept on farms as a business matter, this loss must be replaced by at least a slight gain during the dry weather. It can already be seen that a great improvement has been effected in the young cows at Samaru merely by the elimination of this annually recurring period of starvation during their early years, without any selective breeding. Any substantial improvement of the cattle by selective breeding can only be possible when this annual starvation is prevented.

The other important fact, or at least very reliable deduction, that emerges from the work of Messrs. Anderson and Hartley, is that this loss in weight is not primarily due to lack of minerals or of protein in the grazing. This again is a very valuable piece of knowledge : for

in many parts of Northern Nigeria it would seem that grazing or grass hay must form a considerable part of the diet of even farmers' cattle, if they are to be kept as cheaply as possible.

Mr. Anderson deduces that the deficiencies are " quantitative not qualitative " ; are due to " shortage of food not to lack of balance in the food." By these statements, I presume, Mr. Anderson means that the loss of weight is due mainly to the inadequate net energy value of the diet of the grazing animal. In that case I entirely agree with him. If he had meant that the cause is the inability of the animals to fill their bellies, then I could not have agreed with him, at least as regards many of the cattle in the Northern Provinces, and particularly as regards those in the Zaria Province, in which he was working. Cattle grazing there in the dry weather do not normally appear to be unable to fill themselves. Moreover, an experiment carried out since Mr. Anderson's departure indicates that grass hay, made late in the season from selected grasses, and given as a supplement to grazing, has but little effect in preventing the loss of weight.

Mr. Anderson, in quoting the analyses of grasses carried out by the chemical section of the Department does not include the figures of the contents of the valuable constituents other than minerals and nitrogen, nor the figures for the fibre contents. I refrain from giving these figures, because I hope that a further paper on this aspect of the subject will be published before long by a team of members of the Department. But it may be mentioned that in many of the grasses, when they have shed their seed, the fibre content is so high, and the soluble carbohydrate, ether extract and protein content so low, that the net energy value of such old grass, even of the best species, is extremely low, even if we assume a normal digestibility and neglect the energy used in the walking which the grazing entails.

There are several species of grass which are largely eaten by cattle ; and as we have been studying these grasses agriculturally and chemically only for less than two years, we have still much to learn about them. But it needs little study to see that most, though not all, of the edible grasses are in seed by the end of July. The grazing animal does not, indeed cannot, pick out only such small quantities of young leaves as may be present on such ripe grass. Thus, while the grazing from April to July may be regarded as more or less comparable to ordinary grazing in a more humid climate, from August onwards to October the Nigerian animal is eating an increasingly dry

and dead fodder, of high fibre content, mixed with decreasing proportions of green grass. After that, for five months, the animals are living on grazing which, except for the small amount of regrowth in January, consists entirely of dead mature stems and leaves, with a very high fibre content. Such grazing would seem barely comparable even with the dead "long pulling" in the worst patches of an English pasture in winter. Even assuming a normal digestibility of the food, such a diet can have but little net energy value. With such a diet, in the absence of any green or fermentable food, it is even possible that the digestibility is not normal.

When a full-grown bull can be bought for £1, as it can be to-day in Northern Nigeria, it is clearly out of the question for a farmer to give his young stock much, if any, concentrates. With a milking cow it is different, for milk fetches a relatively very high price here; but, even for a cow, it would be uneconomical to compensate for inferior grazing or inferior fodder by the use of concentrates that represent money, if the grazing or the fodder can be improved at a reasonable cost in labour. No general substantial improvement of the grazing throughout the dry weather appears feasible, though it may well be possible to improve the grazing in the latter part of the rains and early part of the dry season. This matter is being studied; but it is evident that the chief possibility of solving the problem lies in wild grass hay or silage which is made before the grass sets seed, or in fodder or grass crops specially grown for hay, or more probably in a combination of all these. All these questions are now being actively studied.

Mr. Anderson draws attention to a question which then arises. When, as a result of winter feeding and selective breeding, the cattle mature quicker, will they then suffer from some mineral deficiency in their diet although they do not so suffer now? A similar question applies, as he points out, to the improvement of the cows in milk yield and in frequency of calving. The work of Messrs. Anderson and Hartley indicates clearly that this matter will have to be studied again, after a few generations of selective breeding; or at least that it is a point which should not be entirely overlooked. But it may be said that the analyses of our grasses in the earlier stages of growth, and the analyses of the various fodders which are available as by-products of the farm, or which may be grown specially as fodder crops, all, so far as we have gone yet, seem to indicate that there is little cause for such anxiety. It seems that, in Nigeria, when one supplies cattle with a diet of sufficient food value in the ordinary sense, that diet will

probably supply also a sufficiency of minerals, at all events if the customary feeding of common salt or Kanwa is continued.

With regard to the interesting question, upon which Mr. Anderson touches, of the apparent incompatibility of heavy milking with frequent calving among Zebu cows which are kept under native conditions, it may be noted that the same phenomenon is known in India. There, however, my experience of the military dairy farms seemed, even 10 years ago, definitely to have established the fact that the low fertility disappears after two generations of breeding with bulls selected according to the milk records of their dams, provided the cows are well fed and the calves are not allowed to suckle. This practical fact seemed to have been quite clearly demonstrated in India, and already there are indications that it will be confirmed in Nigeria. But, as Mr. Anderson suggests, the part played by each of the three factors which may have helped to cause this result, is an interesting scientific question. An answer would probably be found in the records of the various dairy herds maintained by the Indian Military Department and the various Agricultural Departments in India.

O. T. FAULKNER,
Director of Agriculture, Nigeria.

Ibadan, 7th Sept., 1932.

PREFACE.

On appointment to the staff of the Agricultural Department of Nigeria in 1929, to initiate scientific breeding with a view to improving the native cattle, I devoted the first tour of service almost exclusively to investigating the methods of animal husbandry practised by the native herdowners and the standards of performance of the cattle kept under native conditions. An attempt was made to visualise the problem of cattle improvement in all its bearings. On my return to England on leave I consulted the Imperial Bureaux of Animal Nutrition and Genetics at Aberdeen and Edinburgh and with their help and with that of the Adviser on Animal Health at the Colonial Office, schemes of investigation were drawn up.

These reports describe the preliminary results obtained during the investigations. The work recorded in the first three parts was carried out jointly by Mr. K. T. Hartley, B.Sc., Agricultural Chemist at Samaru, and myself, but circumstances have rendered it impossible for us to present the results in a joint paper, and for the presentation I am therefore solely responsible. Mr. C. B. Taylor, B.Sc., was responsible for the statistical analyses of the data. Messrs J. D. Brown, B.Sc., and K. D. R. Davis, B.Sc., rendered invaluable aid in assisting investigations into the native methods of animal husbandry and in carrying out the experimental work.

I owe a debt of gratitude to members of other departments. The political officers were very helpful and the staff of the Veterinary Department spared no pains in helping me in my investigations. I have great pleasure in acknowledging the help and encouragement I have received from the Imperial Bureaux of Animal Nutrition and Genetics in assisting me to visualise the whole problem, in indicating the lines along which research was necessary and in helping to draw up these reports.

A. W. ANDERSON.

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PART I.

THE COMPOSITION OF THE PASTURES OF NORTHERN NIGERIA.

An extensive survey of the cattle of Northern Nigeria and the methods of animal husbandry practised by the native herdowners, led to the conclusion that the low standard of the cattle was the result of unfavourable environment and was not due to lack of knowledge of selective breeding methods on the part of the owners.

The work of others in South Africa and Kenya suggested that the pasture, in common with other large areas in Africa, might be of poor quality besides being deficient in quantity during the dry season. This was borne out by the result of investigations instigated by the Colonial Office in 1928. Samples of pastures and individual forage plants were sent for analysis to the Department of Agriculture, Union of South Africa, with the following results :—

Percentages on Dry Matter.

	Sol. Ash.	CaO.	P_2O_5.
Natural pasture from characteristic bush	3·68	0·54	0·13
Samaru District natural pasture (upland)	3·77	0·75	0·12
Samaru District natural pasture (wet land)	3·98	0·51	0·13
Good European pasture * . .	6·637	1·00	0·73

These figures confirmed the belief that the pastures were deficient in mineral elements, but as the samples were collected in the autumn when the quality is at its lowest, and the sampling was done by men unaccustomed to this work, it was decided that a complete seasonal analysis of the pastures was desirable.

* Orr, " Minerals in Pastures," London, 1929.

Samples of grass were collected on the last day of each month for twelve months, commencing in June, 1929, from an area on the Stock Farm which was being slightly grazed according to native practice. From January to December, 1931, further samples were collected, twice monthly during the growing season, from the same area. During this period the grass was kept very closely grazed. Only leaves and young succulent stems were included when sampling because it was observed that the cattle avoided old stalks and flowering heads whenever possible.

Determinations were made of soluble ash, nitrogen, phosphorus and calcium, and, in the 1931 samples, of potassium and sodium as well. The results are set out on Table I. The 1930 February

TABLE I.—Shika Pastures.

Results Expressed in Percentages of Dry Matter.

	Sol. Ash.		N.		P_2O_5.		CaO.		K_2O.	Na_2O.
	L.G.	C.G.	L.G.	C.G.	L.G.	C.G.	L.G.	C.G.	C.G.	C.G.
January	3·2	2·08	0·52	2·04	0·14	0·43	0·52	0·53	1·78	0·40
February	2·4	3·16	0·82	1·45	0·15	0·32	0·69	0·37	1·33	0·42
March	5·5	1·84	2·0	1·34	0·43	0·26	0·56	0·59	1·16	0·38
April	3·5	2·40	1·23	2·94	0·16	0·27	0·62	0·53	1·08	0·33
15th April	—	3·60	—	2·75	—	0·45	—	0·41	—	—
May	5·0	4·77	2·04	1·95	0·19	0·45	0·42	0·53	2·54	0·45
15th May	—	1·82	—	1·99	—	0·50	—	0·46	—	—
June	5·5	2·64	1·20	1·67	0·22	0·24	0·44	0·46	1·43	0·61
15th June	—	2·10	—	1·29	—	0·26	—	0·29	—	—
July	4·4	3·59	1·12	1·55	0·25	0·25	0·43	0·48	1·97	1·10
15th July	—	5·80	—	1·06	—	0·21	—	0·37	—	—
August	3·5	3·42	1·19	1·76	0·24	0·28	0·46	0·43	1·13	0·37
15th August	—	3·36	—	1·27	—	0·26	—	0·41	—	—
September	5·3	2·44	0·86	1·43	0·21	0·24	0·43	0·37	1·03	0·39
15th September	—	3·62	—	1·27	—	0·31	—	0·48	—	—
October	3·5	4·10	1·03	1·25	0·22	0·24	0·45	0·37	0·92	0·26
15th October	—	3·12	—	1·48	—	0·31	—	0·42	—	—
November	4·4	2·76	0·81	1·04	0·18	0·27	0·47	0·38	1·17	0·39
15th November	—	3·72	—	0·91	—	0·21	—	0·52	—	—
December	3·8	3·69	0·47	1·05	0·15	0·21	0·52	0·42	1·43	0·36

Note.—L.G. denotes the "lightly grazed" samples which were collected from 30th June, 1929, to 31st May, 1930. The results are tabulated as for a calendar year from 1st January to facilitate comparison.

C.G. denotes the "closely grazed" samples which were collected from the same area as above from 1st January to 1st December, 1931.

sample was not collected by the writer and the figures for this month are not comparable as the sampler collected the tips of the leaves only.

The rains break in April and continue until early October. During the rest of the year no rain falls. The average monthly rainfall for 1930/31 was :—

	April	May	June	July	Aug.	Sept.	Oct.
Rainfall in ins.	2·12	6·88	5·0	9·22	14·98	9·28	0·6

As soon as the rains commence there is a growth of young grass which gradually ripens as the wet season advances and by October has become old and mature. During November and December the pasture becomes withered and if not burned off will persist until the following rainy season. In late December or early January certain grasses start to grow again, especially on low lying lands with a high water table. This regrowth forms the bulk of the grazing from January to May, and, in order to get a true picture of the quality of the pastures as consumed by the cattle, samples were collected of this regrowth from the low pastures during these months.

Table II. gives the analyses of samples collected from the low

TABLE II.—Composition of Pastures Grazed during the Year.

Results Expressed in Percentages of Dry Matter.

Date.	Sol. Ash.	N.	P_2O_5.	CaO.
January	3·4	0·83	0·50	0·57
February	2·68	1·18	0·27	0·70
March	2·28	1·41	0·41	0·89
April	2·72	1·64	0·40	0·67
May	3·44	1·87	0·58	0·59
June	4·44	1·12	0·25	0·43
July	3·5	1·19	0·24	0·46
August	5·3	0·86	0·21	0·43
September	3·5	1·03	0·22	0·46
October	4·4	0·81	0·18	0·47
November	3·8	0·47	0·15	0·52
December	3·2	0·52	0·14	0·52

Note.—Two series of samples, taken in different years, are combined to form this table. The January to June samples were collected in 1931 from low-lying pastures. Those from July to December, in 1929, from higher areas.

lying pastures from January to May and from then onwards from the higher areas. Consequently this Table shows the variation in the quality of the food supply of the cattle in contrast to Table I. which shows the variation for a particular area. The only difference between these is the appreciably higher figures for calcium and phosphorus from January to May in Table II. The seasonal fluctuations in the quality of the pastures follow a normal course. The nitrogen content reaches a maximum when vigorous growth follows the first rains and then steadily diminishes. The phosphorus figures follow a parallel course while the calcium curve tends to rise as the dry season advances. Close grazing improves the quality appreciably in respect of the nitrogen and phosphorus contents but fails to smooth out the seasonal variations.

Samples were collected from seventeen widely separated areas in the Northern Provinces during the growing season and it is of interest to compare the analyses of these with those from the Stock Farm.

Percentages on Dry Matter.

	Stock Farm.		Seventeen other Centres.	
	Average.	Range.	Average.	Range.
Soluble Ash . . .	4·17	5·5–2·4	3·01	5·24–2·16
Nitrogen	1·08	1·87–0·47	0·85	1·60–0·47
Phosphorus (P_2O_5) . .	0·3	0·58–0·14	0·34	0·51–0·20
Calcium (CaO) . . .	0·5	0·89–0·43	0·60	0·91–0·30
Potassium (K_2O) . .	1·5	2·54–1·08	1·40	2·76–0·36
Sodium (Na_2O) . .	0·35	0·59–0·20	0·46	0·76–0·17

The two sets of figures, though not strictly comparable owing to differences in sampling, suffice to show that the grazing at the Stock Farm is not of a markedly different type from that in most parts of the country. A comparison with the results obtained in other parts of Africa is interesting. In the following table the average composition of a medium (Athi Plains) and a poor (Molo) Kenya pasture is given.

Percentages on Dry Matter.

	Nigeria.—Stock Farm.		Athi Plains.		Kenya.—Molo.	
	Av.	Range.	Av.	Range.	Av.	Range.
Sol. Ash .	4·17	5·5 –2·4	3·782	4·758–2·134	2·353	2·974–1·962
N . .	1·08	1·87–0·47	1·239	2·082–0·515	0·951	1·157–0·627
P_2O_5 . .	0·30	0·58–0·14	0·291	0·490–0·110	0·216	0·267–0·111
CaO . .	0·50	0·89–0·43	0·658	0·186–0·506	0·481	0·553–0·399
K_2O . .	1·5	2·54–1·08	1·334	2·065–0·475	0·775	1·018–0·479
Na_2O . .	0·35	0·59–0·20	0·112	0·439–0·021	0·019	0·045–trace

According to these figures the quality of the pasture in the areas sampled in Nigeria is better than that in the Athi Plains and at Molo in East Africa. The Kenya pastures show average P_2O_5 figures of 0·291 and 0·216 respectively compared with 0·30 for Nigeria, the minimum content being 0·11 in Kenya compared with 0·14 in Nigeria. In the phosphorus deficient areas in South Africa where styfsiekte is common, the level of phosphorus in the pastures is even lower than that in East Africa, the lowest level recorded being 0·05.

On the other hand, although the Nigerian pastures are apparently rather better than those of East or South Africa, they are still poor as compared with British cultivated pasture.

Percentage on Dry Matter.

	Sol. Ash.	N.	P_2O_5.	CaO.	K_2O.	Na_2O.
British pasture cultivated (Orr)	6·637	2·82	0·73	1·00	3·17	0·246
Nigerian pasture . . .	4·17	1·08	0·30	0·50	1·50	0·35

SUMMARY.

1. Compared on a dry matter basis with good European standards, Nigerian pastures show a low content of nitrogen, calcium, phosphorus and potassium.

2. There is a normal seasonal variation in the quality of the pastures corresponding to the rainfall curve.

3. There is a valuable regrowth of young grass in January unconnected with rainfall.

4. The quality of the Nigerian pastures compares favourably with that of pastures from other parts of Africa.

PART II.

FEEDING EXPERIMENTS ON NATIVE CATTLE OF NORTHERN NIGERIA.

Introduction.

The cattle of Northern Nigeria belong to a slow maturing breed. They grow slowly, take three or even four years to reach sexual maturity and their milk yield is low. The reproductive rate is slow, with an average interval of eighteen months between calvings.

Field observations suggested that this low level of productivity might be associated with a quantitative deficiency of food, since there is an actual shortage of pasture during the greater part of the dry season.

Further, the results of Theiler (1) in South Africa and of Orr (2) in Kenya have shown that a qualitative deficiency of minerals, especially of phosphorus, may be a limiting factor in growth and reproduction of cattle in other parts of Africa. Theiler's well-known work showed that the feeding of salt and bone meal to cattle grazing in a phosphorus deficient area prevented the development of styfsiekte, a disease due to phosphorus deficiency, and increased the rate of gain in weight in young bullocks and the milk yield of young cows. The work in Kenya showed that in the case of grade milk cows grazing on pastures very poor in minerals, a mineral supplement increased milk production by nearly 30 per cent. As has been shown in Part I., Nigerian pastures are also of poor quality, the most outstanding features being low nitrogen and phosphorus.

A feeding experiment was designed to ascertain how far these adverse factors, quantitative and qualitative, limit production in native cattle in Northern Nigeria. Young native heifers upwards of a year old were selected. Experiments were planned to carry these animals through the final stages of growth to sexual maturity, pregnancy and lactation.

Method.

In February, 1930, 54 white Fulani heifers were brought in. It was found impossible to ascertain their exact ages, which varied, however, between twelve and eighteen months. Six home bred heifers were added to bring the number up to sixty, and on the first of November, 1930, the herd was divided into six groups of ten fed as follows :—

Group 1. Grazing only.
,, 2. ,, + mineral mixture.
,, 3. ,, + protein concentrate.
,, 4. ,, + protein concentrate + mineral mixture.
,, 5. ,, + carbohydrate concentrate.
,, 6. ,, + carbohydrate concentrate + mineral mixture.

All groups according with native custom had periodical access to a native salt lick " Kanwa " which consists mainly of sodium carbonate.

The mineral mixture consisted of equal parts by weight of sodium chloride and steamed bone flour. A weighed quantity of the mixture was placed in a special receptacle and when this had been consumed a further weighed quantity was given. The addition of salt made the mixture less powdery, and by slightly damping it the loss from scattering was reduced to a negligible quantity. For the period of the experiment the daily average consumption of the mineral mixture was :—

Group 2 . . . . 2·7 oz. per head per day.
,, 4 . . . . 1·2 ,, ,, ,,
,, 6 . . . . 2·2 ,, ,, ,,

It is noteworthy that the animals receiving the protein concentrate consistently consumed less of the mixture than the others.

The protein concentrate consisted of three parts by weight of beans to one part of guinea corn. The carbohydrate concentrate consisted of guinea corn alone. The analyses of these concentrates are given in Table I., from which it will be seen that the number of calories fed per day was similar in both rations, but that the bean concentrate contained two and a half times as much digestible protein as the other.

The concentrates were fed in the morning to each animal individually, a record being kept of any which refused to clean up the ration. Three pounds per head per day were fed from January to May, and again during November and December, whilst one and a half pounds

were fed from June to October. All the heifers grazed together during the day and were housed in their respective pens overnight.

Table II., Part I., shows the composition of the pastures grazed during the year. For convenience of description it is best to consider the grazing year as consisting of three distinct seasons :—

(*a*) January-April, when the grazing is scarce but of comparatively good quality.

(*b*) May-October, when the grazing is abundant, of a high quality at the beginning of the period, but deteriorating rapidly later.

(*c*) November and December, when the grazing is abundant but of very poor quality.

A minor complication arises in October when the cattle are allowed to glean the harvest fields and a limited amount of fresh grazing becomes available at the edges of the lowland pastures as the water recedes. This is not accounted for in the Table of Analysis of the pasture.

The cattle were weighed on three consecutive days at the beginning and at the end of the experiment, an average of three weighings being taken as the correct initial and final weight of the individual. At other times weighings were done only once, namely, on the first day of each month. A bull was run with the heifers and a record of the services kept. It is important to note that the service dates correspond to the attainment of sexual maturity as none of the heifers had been in use prior to the commencement of the experiment. Blood samples, drawn from the jugular vein of each animal, were analysed for calcium and inorganic phosphorus four times during the year.

Results.

It took some time to accustom the heifers to the experimental rations, but within two months they were consuming the concentrates and appreciable quantities of the mineral mixture. The 1st January, 1931, therefore, has been taken as the date of the commencement of the experimental period. For various reasons four animals had to be withdrawn early in the experiment, and later eight others were isolated because they reacted to the tuberculin test.

Annual Variation in Weight.

Tables II., III., and IV. give the initial and final weights for each animal which completed the full year. The average gains in each group were :—

Group 1.	Grazing only	. . . . .	118 lbs.
,, 2.	,,	+ mineral mixture	109 ,,
,, 3.	,,	+ protein	240 ,,
,, 4.	,,	+ protein + minerals	232 ,,
,, 5.	,,	+ carbohydrate	205 ,,
,, 6.	,,	+ carbohydrate + minerals . . .	200 ,,

The concentrates (either protein or carbohydrate) produced a markedly significant acceleration in the weight increase. The increases in groups 3 and 4 (protein) are significantly greater than those in groups 5 and 6 (carbohydrate). The addition of the mineral mixture had no effect either by itself or in conjunction with the different concentrates.

Weight Variations from January to April.

As noted previously, this is a period during which grazing is scarce but of good quality. The average gains and losses were :

Group 1.	Grazing only	. . . . .	− 14 lbs.
,, 2.	,,	+ minerals	− 21 ,,
,, 3.	,,	+ protein	+ 17 ,,
,, 4.	,,	+ protein + minerals	+ 24 ,,
,, 5.	,,	+ carbohydrate	+ 23 ,,
,, 6.	,,	+ carbohydrate + minerals . . .	+ 29 ,,

With a standard error of 4·33 there is a significant difference produced by concentrate feeding as such, but none between the different types of concentrate (protein and carbohydrate). Minerals, when given along with concentrates, appear to have had a beneficial effect but the differences between groups 3 and 4 and between groups 5 and 6 are not statistically significant.

Weight Variations from May to October.

This is the wet season, throughout which grazing, of high quality at the beginning of the period but rapidly deteriorating, is abundant. The average gains were :—

Group 1.	Grazing only	. . . . .	+ 155 lbs.
,, 2.	,,	+ minerals	+ 155 ,,
,, 3.	,,	+ protein	+ 187 ,,
,, 4.	,,	+ protein + minerals	+ 180 ,,
,, 5.	,,	+ carbohydrate	+ 181 ,,
,, 6.	,,	+ carbohydrate + minerals . . .	+ 176 ,,

The increase in group 3 may be significantly higher than that in groups 1 and 2, but it would be unsafe to stress the difference. In

the month of May three pounds per head of concentrates were fed, as against one and a half pounds during the rest of the period. If the weights for this month are excluded, the figures are

Group 1	+ 122 lbs.
,, 2	+ 111 ,,
,, 3	+ 128 ,,
,, 4	+ 125 ,,
,, 5	+ 137 ,,
,, 6	+ 123 ,,

and there is no significant difference between the groups.

Weight Variations in November and December.

The average gains and losses were :—

Group 1	— 23·0
,, 2	— 29·0
,, 3	+ 23·0
,, 4	+ 29·7
,, 5	— 0·9
,, 6	— 3·8

Statistical analysis of the data gives a standard error of 2·9.

The four groups fed concentrates showed significantly greater gains than the two without, and the increases due to the protein concentrate are significantly greater than those due to the carbohydrate concentrate. It is noteworthy that during this period the average nitrogen content of the grazing had fallen by over 50 per cent. as compared with that for the other ten months of the year. On the other hand, the addition of the mineral mixture failed to have any significant effect although the phosphorus content of the pasture had also dropped by 50 per cent. when compared with the rest of the grazing season.

Sexual Maturity.

The following summary shows the marked effect of the concentrates in hastening sexual maturity :—

	No. successfully served.
Group 1	2
,, 2	1
,, 3	7
,, 4	7
,, 5	6
,, 6	7

In the groups receiving concentrates 27 out of a total of 32 reached maturity whereas only 3 out of 19 did so in the others. Neither the quality of the concentrate nor the addition of the mineral mixture influenced these results.

General Condition.

At the end of the year it was possible to pick out the two groups which received no concentrates by their leaner condition and narrow, leggy appearance. It was impossible to distinguish between the groups fed minerals plus concentrates from those fed concentrates alone. The group fed minerals without concentrates were indistinguishable from the group receiving grazing only.

Blood Analyses.

The data for the calcium and inorganic phosphorus content of the blood drawn four times from each animal throughout the experiment are as follows :—

Group.	Phosphorus, Mg. per 100 c.c. Blood.		Calcium, Mg. per 100 c.c. Serum.
	Average.	Range.	Average.
1	4·8	3·7–6·9	11·41
2	6·0	4·0–8·5	11·78
3	5·9	4·0–7·4	11·91
4	6·5	4·3–9·3	11·78
5	5·3	4·1–6·4	11·63
6	6·1	3·5–7·4	11·11

The mineral mixture produced a significant rise in inorganic blood phosphorus in groups 2, 4, and 6 as compared with the non-mineral pens 1, 3 and 5. The calcium content of the blood was normal and there was no difference between the various groups.

Discussion.

The results of the experiment show that under the local environmental conditions, and over a period of one year, a caloric deficiency of the pasture is the main factor limiting the growth of

two-year-old native heifers. This is shown by the fact that the feeding of concentrates yielding approximately 2 lbs. of starch equivalent resulted in a 100 per cent. increase in weight and a lowering of the age at which sexual maturity was reached. This result was obtained both by feeding guinea corn (carbohydrate 73 per cent. and protein 9 per cent.) and a mixture of beans and guinea corn (carbohydrate 59 per cent. and protein 23 per cent.). Since protein may be used for purposes of energy production and since carbohydrate cannot replace protein, it may be concluded that the effect of the concentrates was due chiefly to their energy yielding value. Raising the protein content of the ration accelerated the weight increase very significantly during November and December, namely, when the nitrogen content of the pasture is at a minimum, but not at other times. The feeding of a mineral mixture of steamed bone flour and sodium chloride exercised no influence on weight increase, sexual maturity or general condition, but gave a significant increase in blood inorganic phosphorus. The serum calcium remained unaffected.

It is interesting to compare these preliminary observations in growing heifers with those recorded from South Africa (1), where a bone meal and salt supplement resulted in an increased gain in weight, for a sixteen-month period, of about 400 lbs. compared with about 185 lbs. in controls. Equally interesting are the data on the analysis of the blood. In South Africa the average inorganic phosphorus content of the blood of young heifers confined to veld grazing is given as 2·3 mg., rising to 5·2 mg. per 100 c.c. when bone meal was fed. The corresponding figures for lactating cows were 1·5 mg. rising to 3·1 mg. In the case of the Nigerian cattle, the average figure for blood inorganic phosphorus in the control group (grazing only) was 4·8 mg. per 100 c.c., approaching that of South African cattle fed three ounces of bone meal per day. Moreover, six determinations on the blood of lactating cows averaged 3·9 mg. per 100 c.c., in marked contrast to the South African figure of 1·5 mg. per 100 c.c.

These differences are in line with the clinical observations. In the phosphorus deficient areas in South Africa "osteophagia" or bone chewing and styfsiekte, a disease due to phosphorus deficiency, are common, whereas in Nigeria neither of these has been noted. The difference between the Nigerian and South African results is to be attributed to (1) the fact that the pastures in the areas in which tests were done in Nigeria are rather richer in phosphorus than the corresponding areas in South Africa, and (2) that the native cattle of

Nigeria are slower growing than those used in the South African experiments. This is seen in the rate of increase in weight, which was over 50 per cent. greater in the case of the South African cattle.

The results here discussed raise the interesting and important questions of the conditions under which supplementary feeding of protein and minerals is beneficial. The requirements for these depend upon the rate of growth and the rate of production of growth material, i.e. milk. The faster the rate of growth, and the higher the milk yield, the richer must the ration be in these and in other nutrients required as constructive material. This is well illustrated in the case of rickets, a disease due to deficiency in the diet. It is the fastest growing animals which are most susceptible to rickets, inasmuch as their requirements for bone forming materials and accessory factors are greatest.

In experiments on young cattle carried out in Edinburgh and Aberdeen (3) it was found that the addition of supplementary protein, minerals and cod liver oil to a ration of linseed meal and oatmeal had a marked beneficial effect on young cattle, whereas when added to a ration of a somewhat similar composition fed to half grown animals no result was obtained. In these native two-year-old cattle the requirements for both phosphorus and protein would be at a minimum and would be less than those of improved breeds with a more rapid rate of growth. The fact that these native animals have a slower rate of growth and the fact that the minimum phosphorus content of the Nigerian pastures is higher than that of the South African veld is the probable explanation of the difference between the results obtained in Nigeria and those obtained in South Africa.

The point of economic importance brought out by the present trials is that in Northern Nigeria the factors limiting growth seem to be quantitative rather than qualitative. It is absolute shortage of food, not inherent deficiencies in the food, which requires to be rectified to obtain optimum growth. These results apply to native animals over a year old and prior to calving, which is, however, perhaps the least important part of the life cycle of cattle from the point of view of nutrition. Both in Kenya and in South Africa it was found that in lactating animals the factor limiting milk production was the quality of the pasture rather than the quantity ; the addition of bone meal and salt increased milk production by nearly 30 per cent. Whether this result will be obtained in native cattle in Northern Nigeria will be ascertained only when these tests have been carried

over one or two lactation periods. The equally important question of the influence of supplementary feeding on the growth rate of calves cannot be settled until experiments have been continued through several generations.

SUMMARY.

In a feeding experiment conducted over a year with native two-year-old heifers on Northern Nigerian pasture, it has been found that :—

1. Feeding concentrates yielding approximately 2 lbs. of starch equivalent resulted in a 100 per cent. increase in weight and a lowering of the age at which sexual maturity was reached.

2. The effect of raising the protein content of the ration was evident only during the season when the nitrogen content of the natural pastures was lowest.

3. Feeding steamed bone flour and sodium chloride did not influence weight increase, age of reaching sexual maturity, or general condition.

4. It has been shown that the inorganic phosphorus and calcium content of the blood of Nigerian cattle fall within normal limits, but that the former can be raised by feeding bone flour.

5. The importance of continuing these tests throughout lactation and during the earlier and faster phase of growth is emphasised.

TABLE I.—Composition of Concentrates.

[*Per Cent. Fresh Basis.*]

	Guinea Corn.	Beans.
Moisture	11·8	8·4
Fat	2·7	1·9
Protein	9·0	23·5
Carbohydrate	73·2	59·5
Fibre	2·0	2·8
Total ash	1·3	3·9
Starch equivalent	72·5	78·5
Digestible protein	6·8	19·9
P_2O_5	0·54	0·66
CaO	0·04	0·17

Note.—Groups 3 and 4 (receiving 2¼ lbs. beans plus ¾ lb. guinea corn) were receiving 2·3 lbs. starch equivalent, with 0·5 lb. digestible protein. Groups 5 and 6 (receiving 3 lbs. guinea corn) were receiving 2·2 lbs. starch equivalent, with 0·2 lb. digestible protein.

TABLE II.—Table of Weights and Dentition.

Pen No. 1.

	Weight in lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 78	281	387	Nil	4
,, 67	324	454	Nil	2
,, 65	345	484	2	4
,, 92	362	475	Nil	2
,, 87	357	461	Nil	4
,, 111	377	502	Nil	4
,, 74	438	539	2	6
,, 95	431	548	2	4
,, 119	376	500	Nil	4
Mean	365	483		

Average gain 118 lbs.

Pen No. 2.

	Weight in lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 121	233	354	Nil	Nil
,, 84	336	481	Nil	2
,, 63	298	406	Nil	4
,, 60	358	413	2	6
,, 93	342	451	2	4
,, 81	387	514	2	4
,, 114	412	540	2	4
,, 101	409	520	2	4
,, 80	412	534	Nil	4
,, 108	439	503	2	6
Mean	363	472		

Average gain 109 lbs.

TABLE III.—Table of Weights and Dentition.

Pen No. 3.

	Weight in Lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 77	272	523	Nil	2
,, 118	335	609	Nil	4
,, 79	321	550	Nil	4
,, 76	351	564	Nil	4
,, 61	436	695	Nil	4
,, 70	402	638	Nil	2
,, 58	455	673	2	6
,, 69	—	—	Nil	4
Mean	367	607		

Average gain 240 lbs.

Pen No. 4.

	Weight in Lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 116	270	522	Nil	4
,, 96	294	493	Nil	2
,, 102	336	562	Nil	2
,, 71	389	678	2	4
,, 83	382	500	Nil	4
,, 86	393	589	2	6
,, 90	431	700	Nil	4
,, 73	450	659	Nil	4
Mean	68	600		

Average gain 232 lbs.

TABLE IV.—Table of Weights and Dentition.

Pen No. 5.

	Weight in lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 89	307	532	Nil	4
,, 104	351	560	Nil	4
,, 107	367	568	Nil	4
,, 110	370	578	Nil	4
,, 117	370	568	Nil	4
,, 82	385	596	2	4
,, 103	409	589	2	4
,, 59	439	548	Nil	4
,, 85	504	708	4	6
Mean	389	594		

Average gain 205 lbs.

Pen No. 6.

	Weight in lbs.		Dentition. No. of Permanent Incisors.	
	1st Jan., 1931.	31st Dec., 1931.	1st Jan., 1931.	31st Dec., 1931.
No. 115	273	485	Nil	2
,, 64	316	492	Nil	2
,, 100	327	522	Nil	4
,, *68	367	576	Nil	2
,, 62	395	629	2	4
,, 91	403	607	2	6
,, 112	433	598	4	6
,, 97	398	599	Nil	4
Mean	364	564		

Average gain 200 lbs.

PART III.

AN INVESTIGATION INTO THE CAUSE OF PICA IN NIGERIAN CATTLE.

All the herd-owners feed to their cattle, sheep, goats and horses one or other of the numerous native salts sold in the markets of Northern Nigeria.

Full analyses of the Nigerian edible earths and native salts are given by Godden (4). Of those farinkanwa, hereafter referred to as kanwa, is the one most commonly used for the cattle, so the investigations were confined to this salt. A full analysis is given in Table I.

TABLE I.—Composition of Farinkanwa.

By W. Godden, *Rowett Research Institute.*

	Percentage.		Percentage.
Moisture	8·0	Na_2O	10·48
Total ash	88·74	Oxides of Fe and Al	1·42
Acid sol. ash	21·03	P_2O_5	trace
CaO	0·82	SO_3	2·42
MgO	0·30	CO_2	10·71
K_2O	0·31		

With a view to ascertaining why the belief that it was necessary to feed kanwa to cattle was so universal, numerous herd-owners were questioned as to how and when they fed the salt and what happened if it was withheld.

The answers on the whole were rather unsatisfactory and often contradictory. Most of the herd-owners appeared to supply kanwa to their cattle as a traditional practice rather than from the result of personal experience of its benefits. In problems such as this, however, tradition may be a more reliable criterion of the soundness of a practice than isolated personal experiences.

The richest owners allow their cattle free access to kanwa for twenty-

four to forty-eight hours, as often as they can afford, with a minimum interval between feeds of about fourteen days. With others not so well off the intervals may vary from one to six months, according to their ability to buy kanwa. All were agreed that if kanwa was withheld over a long period the cattle developed uneasiness, would not settle down to graze and would lick earth. Some stated that they would lose condition and in extreme cases fail to breed.

The opinion was universal that common salt (sodium chloride) would keep the cattle well during the dry season but that it was more or less useless during the wet season. In this connection it is interesting to note that imported salt is cheaper than the native salts, but the owners will use the former only when compelled to do so by poverty.

Some of the cattlemen laid special stress on the beneficial purgative effects of the native salts. Herd-owners in the Gadabawa district reported that their cattle would almost live in a chalk pit when they were showing pica, but the pica would continue until kanwa was supplied.

When an owner finds that his cattle are discontented and licking earth he supplies one or other of the native salts. If then he finds that some of the cattle refuse to eat kanwa or having eaten still continue to lick earth, he concludes that they are suffering from "mudu," a disease associated with trypanosomiasis. This condition, with its associated pica, is described and discussed by Henderson (5). It seems probable, however, that this "mudu" pica is not closely related to the "normal" pica under discussion here. When an owner takes his "mudu" cattle to a veterinary camp and they are treated with intravenous injections of tartar emetic, the cattle have, in his opinion, been cured because the medicine has enabled them to eat kanwa again!

Experimental.

It was decided to investigate whether the information given by the herd-owners was correct and, if so, why it was necessary to supply these salts to the cattle.

A small herd was fed kanwa periodically up to 16th January, 1930, when the practice was discontinued. Two months afterwards, on the 4th of March, the first symptoms of pica appeared and gradually became more pronounced. The cattle became discontented and restless. They showed a disinclination to go out into the bush to

graze. They licked earth and the cement troughs which previously had contained kanwa. They tried to get to the wood fires to lick the ashes and in spite of precautions succeeded one day. They licked the ashes but the pica was not abated in the least. At no time did they seem to prefer to eat ant hills.

On the 5th of April the herd was divided into three lots, one received kanwa, another a mixture of sodium chloride and steamed bone flour, and the third sodium chloride and a mixture of kanwa and wood ashes, which mixture they refused to eat. The pica disappeared in all three lots. Another pen of cows was allowed free access to steamed bone flour alone. They consumed very little and pica appeared in two months and persisted until kanwa was supplied.

These preliminary trials led to the tentative conclusions that the cattle require kanwa or some salt containing sodium and that the pica is in no way connected with a craving for calcium or phosphorus. Samples of urine were collected over several twenty-four hour periods and showed a low figure for chloride excretion.

These results were submitted to The Imperial Bureau of Animal Nutrition (Aberdeen) for criticism and advice and it was decided to carry out another experiment extending over a longer period and at the same time to investigate the chloride excretion of the cattle.

A herd of twenty-five cows and heifers ranging in age from two to seven or eight years old had to be taken, as they were the only cattle available at the time. Prior to the commencement of the experiment they had been periodically supplied with kanwa. On the 9th of February, 1931, the cattle were allowed to eat as much kanwa as they cared and thereafter all salts were withheld. In two months, on the 17th April, the only two cows in milk in the herd were observed to be licking earth but within three days four maiden heifers were also showing pica. By the 2nd May twenty out of the twenty-five head were licking earth. The symptoms were identical with those described above, but the pica varied in intensity and at times seemed to disappear altogether. In early May, just after the onset, the symptoms were more severe than at any other time. After the first acute craving wore off, adjustment to the altered circumstances seemed to occur. It was observed that the cattle would lick any strange object in the hope apparently that it might contain what they were seeking. Heaps of fresh and partially rotten bones were placed on the ground, but the cattle did not show any greater interest in those than in other strange objects. They smelt and licked them over and then

passed on. They never attempted to chew the bones, although they were inclined to chew pieces of old rag, and lick the attendant's clothing. This may have been co-related with the deposit of salts left in the clothes by sweat. This is in marked contrast to the pica for bones described by the South African workers in the phosphorus deficient areas where styfsiekte occurs.

The cattle appeared to be in good healthy condition all the time and throve as well as others supplied kanwa periodically. The following summary shows the average monthly weight variations in these cattle as compared with eleven others fed kanwa periodically :—

	Average Monthly Weight Variations in Lbs.			
	March.	April.	May.	June.
No kanwa . .	− 16	− 9	+ 33	+ 33
Kanwa fed . .	− 11	− 10	+ 33	+ 35

Not even in May and June did the cattle deprived of salts fall behind the others.

On the 8th of July, 1931, the herd was divided into five lots and the following salts supplied :—

Pen 1. Kanwa.
Pen 2. Sodium chloride.
Pen 3. Sodium carbonate.
Pen 4. A mixture of 4 of sodium chloride to 1 of calcium carbonate by weight.
Pen 5. Control—nil.

A weighed quantity of the salts was placed in special receptacles in each of the pens in which the cattle were housed during the night and the cattle allowed to eat as much as they cared.

Records were kept of the average consumption per head per pen for the first two twenty-four hour periods separately and then at monthly intervals. The following is the record of consumption :—

Date.	Consumption in Oz. Per Head Per Day.			
	Pen 1 (Kanwa).	Pen 2 (NaCl).	Pen 3 (Na_2CO_3).	Pen 4 (NaCl + $CaCO_3$).
8th–9th July . .	8·8	8·8	4·8	3·2
9th–10th July . .	4·0	4·6	0·8	4·0
10th–31st July . .	1·1	1·1	1·1	1·0
1st–31st August . .	1·9	2·0	1·9	1·9
1st–30th September .	1·5	1·0	1·5	1·7
1st–31st October . .	1·2	1·0	1·6	1·4
1st–30th November .	1·2	1·1	0·9	1·2
1st–31st December. .	0·6	1·1	0·4	0·9

For the first two days the kanwa and sodium chloride were consumed ravenously, but the cattle did not relish the taste of sodium carbonate or the mixture of salt and calcium carbonate, although they consumed considerable quantities. After the first engorgement the cattle settled down to consume a fairly constant average quantity per day.

All symptoms of pica disappeared at once except in the case of one heifer in pen 3 which continued to lick earth for three or four days.

Blood samples were drawn from one animal in each of the pens five times during the experiment, the first two when pica was pronounced and the others after salts had been supplied. The following table shows the results of the determinations of the inorganic phosphorus (mg. per 100 c.c.) :—

	1st May.	8th July.	8th July.	3rd Sept.	24th Nov.
			Fed.		
Pen 1	5·0	3·5	Kanwa	3·6	4·7
Pen 2	5·4	4·9	NaCl	3·3	5·1
Pen 3	4·5	4·4	Na_2CO_3	3·4	4·4
Pen 4	4·8	4·4	NaCl + $CaCO_3$	3·8	5·1
Pen 5	4·6	3·6	Nil	3·3	4·6

These figures are normal and show that there was no abnormality in the inorganic phosphorus content of the blood when the cattle were showing pica in May and July. The blood calcium was determined

at the same time as the inorganic phosphorus. The results (mg. per 100 c.c.) also show no correlation with pica :—

	1st May.	8th July.	8th July.	8rd Sept.	24th Nov.
			Fed.		
Pen 1	11·0	10·6	Kanwa	13·5	12·6
Pen 2	12·3	11·1	NaCl	12·6	13·6
Pen 3	12·3	12·6	Na_2CO_3	12·7	13·4
Pen 4	11·7	12·3	NaCl + $CaCO_3$	12·9	13·3
Pen 5	11·2	11·9	nil	14·1	12·3

From these analyses and the observation that steamed bone flour failed to prevent or cure pica, one can safely conclude that the craving shown by the cattle is not due to a phosphorus or calcium deficiency in the diet.

It was observed in the original tentative investigations that the renal chloride excretion was very low and the question arose whether this had any bearing on pica. Complete twenty-four hour samples of urine were collected from five cattle. Their ages varied considerably, but the choice was limited to quiet animals. One man by day and another by night accompanied each cow and collected the urine in a bucket. The total amount voided was weighed and a sample taken for determination of the chlorides. After one or two preliminary trials it was possible to collect all the urine without disturbing the cattle in any way. Samples were collected on the 10th and 14th of February and thereafter weekly until the 7th–8th July. The different salts were fed on the morning of the 8th and samples collected during the twenty-four hour periods 8th–9th and 9th–10th and 14th–15th July. Afterwards samples were collected at monthly intervals.

The following table shows the results summarised into three periods : (*a*) 10th February to 8th July, when no salts were fed and pica became acute ; (*b*) 8th to the 15th July, when large quantities of salts were being consumed ; and (*c*) 19th August to 26th November, when the cattle had settled down to a fairly constant consumption.

	Average Total Urinary Excretion Per Day (Lbs.) and Chlorine (Grammes).									
	Pen 1. Kanwa.		Pen 2. NaCl.		Pen 3. Na_2CO_3.		Pen 4. $NaCl+CaCO_3$.		Pen 5. Nil.	
	Urine.	Cl.	Urine.	Cl.	Urine.	Cl.	Urine.	Cl.	Urine.	Cl.
10th Feb. to 8th July	17·2	9·4	7·8	3·6	9·3	3·2	9·5	3·2	13·8	4·4
8th July to 15th July	15·9	7·2	11·0	30·5	10·0	2·7	13·4	27·1	16·0	2·0
19th August to 26th Nov.	17·0	3·4	6·9	3·6	10·3	1·2	12·5	29·3	16·5	1·8

It would be unwise to stress the importance of these figures as it was almost impossible to make absolutely certain that all the urine had been collected in every case. As a rough guide they are interesting. No. 2, fed sodium chloride, appears to have retained an appreciable amount of the chlorine, whereas No. 4 fed sodium chloride and calcium carbonate with a daily excretion of 29·3 g. could not have been storing any.

Nos. 1, 3 and 5 receiving kanwa, sodium carbonate or nothing show very consistent averages for the chlorine excretion which drops appreciably as the year advances. A comparison between No. 5 and Nos. 1 and 3 shows that neither the presence of pica nor the addition of sodium to the ration appears to affect the chlorine excretion in any way, for No. 5 showed pica right up to the end. The chlorine content of the pastures was not determined, but it would appear from these figures that the pica is not related to any upset in the chlorine metabolism.

Since, therefore, the pica disappeared as soon as the different salts were supplied and the pen which was kept as a control, and received nothing, continued to show pica spasmodically up to the end of the experiment, it seems obvious that the pica is due to a craving for sodium, and the metabolism of phosphorus, calcium and chlorine appears to be unaffected.

Analyses show that the sodium content of the grazings compares favourably with that of good European pastures, namely 0·35 per cent. of the dry matter as against 0·25 per cent., and the sodium potassium ratio of 1 : 4·3 is much closer than the 1 : 12·8 ratio in European pastures.

It is difficult, therefore, to give a satisfactory explanation of this craving for sodium unless the requirements for this element are abnormally high in tropical semi-arid countries. Records were kept of the amount of water consumed and when the moisture content of the grass was as low as 61 per cent. and the humidity of the atmosphere had fallen to as low as 17, cows allowed fresh water *ad lib.* consumed only 38 lbs. per head per day. Native cattle are penned at 6 p.m. and not liberated until 9-10 a.m. and it might be supposed that their first endeavour would be to satisfy their thirst. Instead they show no inclination to hasten to water and will graze leisurely towards the watering place, arriving about mid-day. If shade is available they will often rest and chew the cud before drinking. In contrast it is interesting to note that a half-bred heifer (red poll × native) invariably made straight for the watering place. It may be that the ability of these cattle to exist on an abnormally low water consumption is somehow associated with the need for salts. The importance of this problem in the semi-arid regions of the Empire would appear to justify research along these lines.

The possibility that the craving for these salt licks may be due merely to an acquired taste and not to any physiological need cannot be dismissed without consideration. Cattle allowed access to kanwa *at all times* consumed on an average about 33 ozs. per month, whereas others fed the salt for periods of twenty-four hours twice a month consumed only an average of about 8 ozs. per head per month and remained healthy without pica. Obviously cattle will consume quantities far in excess of any possible physiological requirements if the opportunity presents itself. Further, pica is most pronounced two or three months after the feeding of kanwa is stopped and then seems to diminish. Over the short period of the experiment described the cattle deprived of salts did not lose condition and those that went on without salts to the end of December were indistinguishable from the others except in that they continued to show pica.

Against all this, however, must be placed the indisputable evidence that the cattle persisted in licking the obviously unpalatable sodium carbonate until they cured themselves of pica, and acquired a liking for it. However much they licked other substances not containing sodium the pica still persisted.

Although it has been demonstrated that it is the sodium in the kanwa that controls pica it does not follow that all the other elements in kanwa are useless. This experiment has been carried out over a

comparatively short period and it will be necessary to continue for two or three years before any definite conclusions can be drawn as to whether these other elements are essential. It is possible, in fact probable, that it will be found that the simple sodium salts cannot replace kanwa entirely. The experience of years cannot be dismissed as erroneous on results of a short-time experiment like this.

It is of the greatest importance that the complete rôle played by kanwa in the nutrition of these cattle be investigated. It is possible that one or more of the elements present in small quantities, or even as traces, may, over a long period, exert a profound influence. Until this problem has been thoroughly investigated it will be impossible to form any clear conception of all the factors that may be affecting the development of the cattle, and after further investigation it might be possible to supply a mixture of salts better than kanwa.

SUMMARY.

In an experiment on a mixed herd of cows and heifers it has been found that :

1. Pica can be controlled by supplying sodium in the form of a simple salt, sodium carbonate.

2. The pica is not associated with a calcium or phosphorus deficiency in the diet.

3. The metabolism of phosphorus, calcium and chlorine appears to be normal whether sodium is supplied or not.

4. The need for further investigation into the exact rôle played by kanwa is emphasised.

PART IV.

SOME PROBLEMS OF ANIMAL HUSBANDRY IN NORTHERN NIGERIA.

Introduction.

When it was decided that it was desirable to attempt to improve the cattle of Northern Nigeria the problem appeared comparatively simple. Reasoning from the assumption that the cattle were "quite unimproved" the main object appeared to be to evolve by selective breeding superior bulls of the indigenous breeds of cattle for the improvement of the local stock. An extensive survey of the cattle and methods of management and selective breeding adopted by the native herd-owners demonstrated very clearly that the problems were many and complex. A doubt arose as to whether the cattle were "quite unimproved" and as to what would constitute a "superior" bull under the conditions of the environment. To appreciate the various aspects of the problem it will be necessary to describe the conditions under which the cattle live, their standard of performance under these conditions and the methods of selective breeding adopted by the native herd-owners in the past.

General Conditions.

Apart from the small "pagan" cattle which form a very insignificant percentage of the stock, the cattle were brought to Northern Nigeria by a nomadic race, the Fulani. A portion of this tribe has settled to cultivate the soil and a small percentage of the more prosperous Hausa farmers have managed to acquire cattle, which, however, are almost invariably managed by Fulani herdsmen. The development and management of the cattle has therefore been, and still is, in the hands of this tribe. Over seventy per cent. of the cattle are owned by nomads who do not farm. In cases where the owners do farm, the cattle are seldom or never incorporated into the general

economy of the farm. The nomads depend almost entirely on the milk yield of their cows for their livelihood. They consume large quantities themselves and sell butter and butter-milk to buy corn and other necessities of life. The farmers are not so dependent on the milk supply but their herds are usually small.

Climate.—The rainfall occurs at a definite period of the year. The rains start in April and continue till early October, but the total rainfall varies considerably in different districts. Along the northern boundary the total rainfall is very meagre while in the southern districts the dry season is comparatively short. During the dry season the humidity of the atmosphere is very low.

Nomadism.—During the wet season grass is plentiful in most districts but throughout the dry season it is scarce except in the low lying lands with a high water table. In these circumstances a seasonal movement of the cattle is inevitable. The excessive rains of the South, coupled with overrank vegetation and flooding, compel an exodus when the rains commence. The advance of the dry season causes a gradual disappearance of the food supply and in consequence a movement back to the moisture-retaining areas. The movement is practically universal. The farmer with a moderate sized herd leaves his farm in search of fodder when the near-hand grazing is exhausted. The farmer with a small herd cannot afford to move with his family so several unite their cattle to form one joint herd which is sent off in charge of one man. Except for a few cows retained at home to supply milk, all cattle are moved in search of grazing. When it is considered that all grazing is free and the area practically unlimited it would appear that this movement of the cattle with the grass supply is the least expensive method of tiding over the difficult periods.

Native Husbandry.—The herds graze over wide areas during the day and are penned at night in rude enclosures. They are liberated about 10 a.m. Enquiries as to why the cattle were kept penned to such a late hour invariably elicited the reply that if the cattle are allowed to graze before the dew is off the grass they become unhealthy. The belief is founded on tradition and there does not appear to be any experimental evidence to show whether the danger is due to the presence of parasites or to other causes.

Cows are milked as much as they will give freely and the calf is then allowed to draw the remainder. Milking is done once or twice per day according to the milk yield of the individual cow and the

family requirements for milk. A very poor milker may not be milked at all. Milking commences three days to three months after calving, again depending on the individual cow and the family requirements which are considered before those of the calf. This is especially true of the small herd-owners who live near villages and sell milk. The large herd-owners can afford to treat their calves more generously and the result is obvious on inspection.

The Cattle.

With the exception of the small percentage of humpless cattle owned by the Pagans the cattle are all of the Zebu type. Modifications in type occur in the different areas but generally their conformation leaves much to be desired. The outstanding feature is their narrowness when viewed from front or back and their drooping hindquarters. They weigh much less than one would judge from their appearance. The cattle belonging to the "settled" owners and those in the extreme northern areas, where grazing is very scarce, are small and more compact than those owned by the nomads.

Growth.—The rate of growth is very slow. At the Stock Farm the average weight at birth is about 40 lbs., varying from 21 to 55 lbs. The average weight of 57 two-year-old heifers was only 369 lbs. Full growth is attained about the seventh to the tenth year and well conditioned bullocks may reach 8 to 10 cwts.

Sexual Maturity.—Bulls reach sexual maturity when about four years old, and heifers at a slightly earlier age, about $3\frac{1}{2}$ years old. When the grazings are plentiful and of good quality sexual maturity is hastened.

Milk Yield.—The milk yield under native conditions is difficult to ascertain exactly but it is certainly very low. It would appear that the maximum is about a gallon and a half per day even in the full flow. The majority of cows yield less than this. The average is probably somewhere between one half and one gallon.

It has been found impossible to arrive at even an approximate figure for an average lactation yield under native conditions. At the Stock Farm, where the cattle were kept under approximately native conditions, the average for the cows recorded is about 90 gallons, while at Samaru, where the cattle were fed concentrates, the averages range from 131 gallons in 1928 to 170 gallons in 1931. The majority of cows go dry very rapidly after effective service.

Breeding Efficiency.—Many cows calve annually but others calve only once in two, three or even four years. The groups are clearly defined. A cow does not normally calve once a year at one time in her life and then once in two or three years at another. The biennial calver remains distinct from the annual calver, although it is not suggested that these terms mean exactly 24 and 12 months respectively. Taking all the different groups, the average interval between calves for all cows is probably about eighteen months.

Breeding Methods of the Herd-owners.

Bulls not intended for stock purposes are sterilised when about three years old, i.e. just before they would become troublesome. Sterilisation is accomplished by crushing the spermatic cord between two stones. The belief is general that bullocks sterilised early in life do not grow so well. On the other hand, as a sort of insurance against disease, etc., more bulls are kept than is necessary. These surplus bulls are not allowed to serve so long as the stock bull is available. In Bornu, where most of the cattle are owned by small herd-owners (Shuwa Arabs) and are grazed in composite herds, a special stock bull is kept to serve the best cows.

It has been noted above that some cows calve annually and others every second year or even only once in three years. The Fulani and the Shuwa Arabs are convinced that frequency of calving bears a close relationship to the milk yield. The period that elapses between calving and the recurrence of ovulation depends on the milking capacity of the individual, the lower the yield the shorter being the period. The best milkers may not come in service until they go dry. A query as to whether a particular cow was a good milker was answered " No, she calves every year." The herd-owners are convinced that this " frequency " or " infrequency " of calving is inherited in a sex-linked manner through the sire.

The dependence on milk for a livelihood and the size of the individual herd have a very important influence on the breeding policy of the owner. The choice is limited to breeding for individual high yielders or for numbers. Owners of small or moderately sized herds who have many wives and big families are compelled to breed for milk. The result is that they have great difficulty in increasing the size of their herds. Owners of large herds have many cows in milk so they can afford to breed for numbers. Whatever his aim may be

the owner carefully selects his bull to meet his particular requirements. While the individual merit of the bull is considered, stress is laid on the bull's dam and her family. The Fulani word for "stock bull" was interpreted by a political officer as "a good bull whose ancestors are known." So carefully indeed is the stock bull chosen that in the Eastern districts where herds are large, the stockman in need of a bull will buy a likely cow with a bull calf at foot. If the cow proves satisfactory the bull is used, if not he will be discarded. They prefer to use their home-bred bulls from their best cows. When herd-owners in Bornu Province were asked to explain what influenced them in choosing a bull for their herds they replied that the dam and granddam must have been good milkers, but if the bull himself is of a long legged type which grows very thin during the long dry season, they will not use him. It was found that stock bulls had been carefully chosen in all cases except where poverty in the very small herds or disaster through disease had afflicted the herds.

Surrounding the Veterinary Farm at Vom a large reserved area has been established for a considerable number of years. Movement in this area has been restricted so that epidemics have been avoided or kept under control. Figures for the annual percentage increase within the individual herds in this area, where the death rate has been reduced to normal, are interesting. One herd in the area for seven years made an average annual increase of just over 10 per cent. The owner stated that he liked moderate milkers and calves. Another herd had made an average increase of over 16 per cent. The owner stated that he preferred calves to milk and always used a bull from an annual calver. The owner of a third herd which showed an annual increase of only 8 per cent. over six years, lived near a village and sold milk. He was very emphatic that he would only use a bull from a good milker. A fourth herd had an annual increase of just under 12 per cent., following an objective of good milkers with plenty of calves. These four typical instances clearly demonstrate in practice the soundness of the genetic theories held by the herd-owners.

The care exercised in choosing the sire does not apply with regard to the female. Every female is regarded as a fit subject for breeding and a cow is never sold for slaughter unless something has gone wrong. This would normally have little influence in retarding improvement. There are, however, two abnormalities which occur amongst the cows and which are propagated by this indiscriminate breeding from all females. The first is that of the cow that calves down and gives no

milk at all. She is known by the name " dakali." There are no external indications that the animal is abnormal before parturition. The udder " springs " apparently quite normally but afterwards no milk is secreted. This continues during the entire life of the cow. The owner is well aware that the progeny of such a cow after a normal sire will be normal and that the cow herself will breed regularly and often, so she is retained. The second abnormality is the " refuser." Periodically a cow appears which refuses to nurse her calf or allow herself to be milked. This is not a simple case of puerperal mania. The cow shows no violence towards her offspring or human beings but persistently refuses to let her milk down. She is retained in the herd for the same reasons as the " dakali " is, with the added inducement that she may become normal with her third or fourth calf. It would appear that these two presumably recessive undesirable characters keep cropping up because of the indiscriminate breeding from all females.

Inbreeding is intense. The majority of owners prefer to use a home-bred bull. Father on daughter, son on dam, and even brother on sister matings are the rule rather than the exception. In some districts there is a superstition against son on dam matings, but this appears to be the only restriction. When a herd-owner dies his herd is divided equally amongst his sons, after a small share has been allotted to the daughters. In the majority of cases the sons keep together so even if there is an interchange of bulls the inbreeding must be very close. All the cattle must be extraordinarily homozygous. An outcross by a bull from another herd does not appear to produce any hybrid vigour and there is little evidence that really undesirable recessive characters appear, unless the " dakali " and the " refuser " are instances. This is surely an indication of the vast number of years over which selective breeding has been intelligently practised.

Deductions.—From the above description it is obvious that the Fulani and the Shuwa Arabs are capable herdsmen, and, so far as the actual handling of the stock or selective breeding is concerned, we have little to teach them. The cattle are certainly not " quite unimproved " so the whole problem must be viewed from a different angle. In fact the possibility that further " improvement " would not be economically justifiable has to be seriously considered.

The query naturally arises why, if the herd-owners know their business so well, greater progress has not been made, or why the performance of the cattle is on such a low standard. If asked to

select the best cow in a herd the native will invariably pick one in accordance with generally accepted European standards. At an agricultural show two native herd-owners and the writer were asked to judge a class of 65 cows and the first four cows were selected by all three judges quite independently. The absence of progress therefore is not a question of different standards and aims. The reason for the existing low standard must be sought in environmental limiting factors. These include the prevalence of disease and the quantity and quality of the food and water supply.

Factors Limiting Improvement of Cattle.

Prevalence of Disease.—It has already been noted that, if possible, all females are retained for breeding and that probably the average interval between calves is about eighteen months. If, in a herd, cows calve once in eighteen months, if 10 per cent. of the young stock die, if the sexes of the survivors are equally divided, if heifers calve down when four years old, if males are sold when seven years old and a 10 per cent. culling of breeding cows is allowed annually, then an annual increase in the herd of 11·8 per cent. would accrue. In the reserved area at Vom the average annual increase in twenty-four herds was just under 12 per cent., while the cattle census shows an annual increase of 10 per cent. in the whole area. It may be assumed that, under normally favourable conditions, there ought to be an annual increase in the cattle population of about 11 per cent., and any marked falling short of this figure is due to outbreaks of disease.

An examination of the Nigerian Cattle Census (Table I.) clearly demonstrates the toll exacted by disease. From 1921 to 1928 there was a decrease of over 15 per cent. which, if added to the potential increase of 11 per cent., gives a mortality of over 26 per cent. In other words one out of every four must have died. The chief of these diseases is rinderpest which periodically wipes out whole herds. In the first epidemic in the early nineties, when the losses were extremely severe, many of the owners committed suicide. Owners have been interviewed who have lost all their cattle more than once, and one related how his herd of 300 head had been reduced to two. The whole outlook of the owners is coloured by this ever present dread and their efforts towards improvement extending over many years have often been completely lost in as many days.

When the Veterinary Department has succeeded in controlling

serious outbreaks of disease, and on the assumption that no diseases are introduced, there will be a gradual levelling up of the quality of the cattle. The periodic retrogressions due to losses will be eliminated. The solution of this difficulty will be a big step forward but it will be negative rather than constructive in its results. There will be no raising of the standard of the best cattle.

There are indications that the cattle also suffer from non-lethal diseases which retard growth and maturity and may affect the milk yield. This aspect of the problem merits further investigation.

The Food Supply.—There are two distinct sides to this question, namely, deficiency in (*a*) quantity and (*b*) quality.

(*a*) *Quantity of Food.*

Milk for Calves.—It has been previously noted that the herd-owners depend almost entirely on milk for their livelihood ; consequently the amount of milk available for the calves will depend on the total milk supply and the requirements of the owner. Except in the large herds the calves frequently suffer. The Hausa farmers, who are not so dependent on milk, invariably starve their calves because they have a ready market for the milk. Indeed, they are never good stockmen. It is difficult to assess the full effect of this starvation in early life on the subsequent performance of the individual but it must be considerable. It is even more difficult to suggest a remedy. " So long as there is a demand for milk and milk products and the cows are poor milkers this state of affairs will continue.

Starvation during the Dry Season.—In Part II. it has been shown that young cattle kept " native fashion " lost on an average 48 lbs. per head or 13 per cent. of their original weight during the dry season. Others fed concentrates gained an average of 32 lbs. per head. Even if it be conceded that a 32 lb. gain in six months is satisfactory, the practice of feeding concentrates cannot be justified on economic grounds. The cattle consumed 5 cwts. per head, which would have cost somewhere in the neighbourhood of £1 in an average year. There was not half that difference in value between the different groups ; in fact, the best were not worth more than 25s. in all at the end of the dry season. The experiment was designed to throw light on the problems in connection with the dry season and not to prove whether feeding concentrates was economically sound or not. It might be possible to supply the necessary food constituents in the form of hay or silage at a cheaper rate. To justify this the cost must be almost nil. The annual cost of keeping a cow is at most 10s. per annum (2s. tax and

8s. for native salts). With an overhead charge so low even a very small additional expenditure represents a large percentage increase in the cost of production. It has been continually emphasised that there is an unsatisfied and almost unlimited market for meat in the Southern Provinces, but due emphasis has not been laid on the fact that the market is for *cheap* meat. In the slump in 1931, although presumably the Southern population had not lost their craving for meat, the financial situation was such that cattle were practically unsaleable at any price. The same applies to the demand for milk in the northern towns and villages. The article must be so cheap that the owner can never hope to recoup himself for extra cost of production by increased production. The margin for profit is so narrow and the overhead charges so low that it pays better to increase production through numbers than by feeding. Moving the cattle with the food supply and facing the risks involved appears to be the only economic method until the consumers are able to pay higher prices for the products.

On the other hand, the departmental policy of trying to induce the ordinary farmer to keep cattle on a proper mixed farming basis may be economically sound, for the possible extra cost of production will be offset by the increased fertility of the farm. Pushed to a successful conclusion this policy may have a considerable influence on this aspect of the problem so far as the small herds are concerned.

(*b*) *Quality of Food.*

This has been discussed in Part II. where the need for further research is emphasised. It would be futile to discuss the possibility of economically supplementing the deficiencies in quality or to try to anticipate the potential limiting factors if the cattle are "improved" until such time as the exact nature of these deficiencies has been placed beyond doubt.

Water.—In certain parts of the northern areas water shortage is acute during the whole of the dry season. In some parts cattle have to be moved owing to water shortage before the grazings are exhausted. These cattle have acquired an extraordinary ability to exist on a very low water intake even in this hot country where the humidity of the atmosphere falls to extremely low levels. This is discussed in Part III. The question here is, is it possible to evolve a high yielding cow with a low water requirement? If the answer is in the negative, and the evidence favours such a conclusion, the problem becomes even more complex. It seriously limits the possibility of the extension

of the practice of keeping the cows on the farm and strengthens the arguments in favour of nomadism. If by selective breeding for more obviously desirable characteristics the power of these cattle to exist on a low water consumption is lost, the result will be more harmful than otherwise.

Milk Yield and Reproductive Rate.

It will be convenient to discuss the inverse correlation between the milk yield and the reproductive rate, because it is possible that the deficiencies in quantity and quality of the food supply might be partly responsible.

Of all the herd-owners interviewed during twelve months of almost continuous travelling, only one insisted that he had known an annual calver to be as good a milker as others which calved at longer intervals. Reasoning that the known deficiencies in the quality, and, at certain seasons, in the quantity of the food supply, were such as to limit either milk yield or reproduction it was concluded that this correlation was simply a question of malnutrition, that the inherited milking capacity regulated the reproductive rate because of unfavourable environmental conditions. When this problem was discussed at The Imperial Bureau of Animal Genetics and with Dr. Marshall of Cambridge it was suggested that it was improbable that this explanation would fit all the facts and that the reproductive rate was probably inherited independently.

The recorded milk yield and the reproductive rates of the cattle under European supervision are analysed in Table II. Unfortunately owing to the short time over which records have been kept, only very few animals with several normal lactations are available. The following summary shows the position at a glance :—

SUMMARY OF TABLE II.

	Group I. Calving Interval 12 Months or Under.	Group II. Calving Interval Over 12 Months.
No. of cows . . .	6	5
No. of lactations . .	14	12
Av. days in milk . .	204	362
Av. total yield . .	1354 lbs.	2577 lbs.
Av. daily yield . .	6·6 lbs.	7·1 lbs.

The average daily yields in the two groups are not really comparable. In group I. the cows went dry more or less normally, but in Group II. the cows were only just, or not in calf when they started to go dry and the recorded lactations were prolonged for weeks after the yield had fallen to practically nothing. Under normal circumstances the number of days in milk in Group II. would be considerably curtailed, with a rise in the average daily yield but without a corresponding drop in the total yield.

During the observation period the cattle were fed lavishly, so that the disturbing factor of periodic starvation has been eliminated, although it is not quite so certain that the quality of the diet was all that could be desired.

It would be unwise to stress unduly the significance of these figures relating to so few cows. As a general indication of the performance of the cattle under good conditions they are interesting. Although the cattle have been well fed an inverse relationship between milking capacity and frequency of calving remains, and does not, therefore, appear to be due to malnutrition. In Group II. feeding has failed to bring the reproductive rate up to that in Group I. and the general average yield of the annual calvers is still low. Cow No. 14 in Group I. is an outstanding exception. Over three lactations she averaged 2321 lbs. in 271 days with an average interval between calves of 343 days. Cow No. 19 produced 2875 lbs. at her first lactation and calved again in 352 days, although she fell off considerably in subsequent lactations. It is doubtful whether these two cows could have put up a similar performance under native conditions and they are interesting as showing that, under favourable circumstances, exceptions to the general rule may be expected at least in the Shuwa breed. On the Stock Farm, where the cattle were kept as nearly as possible on native lines, one " White Fulani " cow out of about fifty, proved to be a comparatively high yielding annual calver.

It is still possible to argue that the correlation may be due to deficiencies in the quality of the diet since, although these cows were fed a diet of adequate caloric value and remained in good condition, the food may have been deficient in quality. In Part I. it has been shown that the pastures are of low nutritive value as compared with European standards. In certain areas where the quality of the grazings is much above the average, the cattle do correspondingly better. They thrive well and reach sexual maturity fully a year earlier than in other parts, but the owners still insist that the annual

calver is a poor milker. Mr. K. D. R. Davis, late of the Agricultural Department, had occasion to visit the Lau and Jalingo areas, where he was very much struck with the quality and general well-being of the cattle, but although subsequent analysis showed the pastures to be much above the average in quality, he reported that even in these areas it seems to be impossible to produce milk and calves.

It would appear therefore that " milking capacity " and " reproductive rate " are inherited with a marked tendency for " high yield " to be associated with a slow reproductive rate, but this association is accentuated by the unfavourable environment.

The practical value of these observations appears to lie in selection for milking capacity along with high reproductive rate. The annual calver is, on the average, a poor milker and the high yielder a shy breeder, but, under favourable circumstances, an appreciable number of annual calvers will be found which have a comparatively high yielding capacity. All the evidence points to the " reproductive rate " being inherited in a sex-linked manner through the sire and the general trend of modern opinion is that the factors for high milk yield are probably inherited in a similar manner. Therefore, only sires from the exceptionally good milkers which calve regularly every year should ever be used. It is almost impossible to exaggerate the importance of this in the improvement of the cattle of Northern Nigeria. It would be possible to speed up the reproductive rate in a comparatively short time by using only bulls from annual calvers, and from the facts now in our possession, it would appear to be possible to evolve comparatively good milkers which will calve every year. The really high yielding cow, requiring supplementary feeding to keep up the yield and the reproductive rate can never be an economical proposition. Hence the best solution appears to lie in increased numbers of moderate performers.

Improvement by Cross Breeding.—When the Stock Farm was started, the original objective was to produce, by selective and scientific breeding, superior bulls of the indigenous breeds, and strangely enough one of the biggest difficulties has been to be certain what would constitute a " superior " bull. That the characteristics and performances of the European breeds cannot be accepted as a standard is clearly proved in the following experience.

Some few years ago the Emir of Katsina imported a red poll bull for use in his herd. The bull sired 35 calves, of which 31 died within one year after weaning. It is reported that they were better than their

dams and grew very quickly when being fed milk, but none survived to reach sexual maturity. The other four were sent to the Veterinary Department. One bull died and one heifer met with an accident and had to be destroyed. One bull and one heifer still survive. These half-breds arrived at Vom when approximately one year old and at that age they weighed almost as much as the native two-year-olds. They were not pampered in any way and were allowed to run with the native herds. Although no record of weight increase has been kept they grew very slowly and when about five years old were no heavier than native cattle of the same age nor are they superior in quality. The bull reached sexual maturity when he was over three years old and the heifer came in service for the first time when she was three years and three months old.

The actual result therefore of using an "improved" bull in the existing environmental conditions has resulted in an extraordinary death rate with two survivors out of thirty-five, and these are not in any way superior to the native stock. However "superior" this red poll bull may have been in England it is obvious that the same adjective cannot be applied to the animal in Nigeria.

Deductions.—Quality, as it is generally understood, is valueless in Nigeria from a beef point of view. The demand is for cheap bulk, so that time spent in trying to improve the beef qualities, even if this were economically possible, would be largely wasted. Until such time as the investigations into the problems of the food and water supply have been brought to a successful conclusion and so long as the economics of production remain as at present, a "superior" bull must be defined as one genetically pure for moderate milk yield and regular annual calving. If the physiological and economical limiting factors cannot be thoroughly investigated and removed it will require serious consideration whether expenditure on trying to evolve an animal of so low a standard of superiority can be justified in view of the standard achieved already by the best natives themselves.

TABLE I.—Nigeria Cattle Census, 1921–1928.

1921—3,624,298.
1922—2,909,710—3 per cent. increase.
1923—2,750,642—5·4 per cent. decrease.
1924—2,676,440—2·7 per cent. decrease.
1925—2,864,186—7 per cent. increase.
1926—3,162,328—10·4 per cent. increase.
1927—2,996,679—5·2 per cent. decrease.
1928—3,072,600—2·5 per cent. increase.

TABLE II.—Table of Milk Yield and Reproductive Rates.

Group I. Calving Interval 12 Months or Under.				Group II. Calving Interval over 12 Months.			
Cow No.	Lactation.	Days in Milk.	Milk Yield. Lbs.	Cow No.	Lactation.	Days in Milk.	Milk Yield. Lbs.
11	1st	109	849	3	1st	397	4235
	2nd	133	234		2nd	452	3169
	3rd	163	881		3rd	348	3183
12	2nd	119	65	5	2nd	348	1902
	3rd	77	85		3rd	354	2325
16	2nd	331	1898	9	1st	165	946
	3rd	186	1235		2nd	328	1866
19	1st	289	2880		3rd	432	1748
	2nd	245	1679	32	2nd	375	2873
	3rd	196	1263		3rd	399	2055
34	1st	192	937	7	1st	427	3414
14	2nd	314	3032		2nd	321	3219
	3rd	221	1030				
	4th	278	2900				

SUMMARY.

1. Nigerian pastures are of low feeding value, especially during the dry season. As judged by chemical standards the mineral balance does not appear to be abnormal but pica is prevalent and is prevented or cured by administration of sodium. Increasing the caloric, but not the mineral intake, improves rate of weight increase and hastens sexual maturity.

2. The standard of the cattle is very low in spite of careful selective breeding on the part of herd-owners. Environmental conditions are such that improvement by importation of European stock is impossible. With the maximum improvement in nutritional conditions economically possible, the most advantageous policy appears to be to breed within the existing herds for a combination of high milk yield and high reproductive rate.

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